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A New Interior-Filling Algorithm Based on Binary Boundary Coding

(이진 경계 코드를 이용한 새로운 영역채움 알고리듬)

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要 約

패턴 인식과 영상 처리에 있어서 경계선으로 둘러 쌓인 영역의 내부를 채우는 것은 가장 일반적인 문제 중의 하나이다. 지금까지 제안된 방법으로는 패리티(parity)검사법, 시드(seed) 확장법 그리고 체인코드(chain code)를 이용한 방법등이 있다. 본 논문에서는 경계선 내부영역을 채우는 새로운 알고리듬을 제안하였다. 본 알고리듬은 이진으로 코드화된 방향정보를 이용하여 기존 방법들의 단점을 보완하는 효과적인 방법이다.

Abstract

One of the most common problems in pattern recognition and image processing is filling the interior of a region when its contour is given. The existing algorithms of the filling are parity check technique, seeding technique, and technique based on chain coding the boundaries. In this paper, a very simple but effective technique for filling the interior of bounded region is proposed. This algorithm is based on the information of binary-coded boundary direction and covers some of the drawbacks reported in the earlier relevant works.

I. Introduction

Filling the interior of a region when its contour is given is one of the most common problems in many applications of image processing, patten recognition in which many algorithms compute integrals over the area of a region and require knowledge of the interior, pictorial data base, recovering inside of compressed edge data, image analysis, etc.

Parity check algorithm [1-3], which has been mostly used for the case, is based on the fact that a straight line intersects any closed curve (such as the contour of a region) an even number of times. If we know that the first point of the line lies outside the region, then we can traverse it and decide which segments belong to the interior by counting the number of intersections. If the count is odd, then the segment belongs to the interior otherwise it does not. This algorithm, however, has two serious problems. First, it is

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possible to have points from two or more sides mapped on the same pixel, and this produces an incorrect count of the number of intersections. Second, problems may arise from lines of contact that must be counted twice as an intersection.

Connectivity filling technique is known as the seeding technique [4-6], where an interior point (as a seed) is given in addition to the contour. It performs traverse over the plane to find all pixels that can be reached from the seed without crossing the contour. This technique is better version than the parity check technique but it has major disadvantages as follows: the need to know in advance an interior point (seed) which in some application may be difficult to find and if a figure has a connected contour but a non-connected interior, then only the part containing the seed will be filled. To compensate this, a combination algorithm that fills some parts of the contour by a parity check and others by connectivity filling has been proposed[1]. This algorithm can fill all part of the interior, but it is a computationally costly method.

An algorithm for extracting the interior of bounded regions based on the chain-coding method was recently proposed[4]. This technique is computationally faster than the earlier relevant works and has ability to discriminate between open and closed boundaries, but it requires complicated comparisons for the classification of the points as a part of the interior or not.

In this paper, we shall introduce a very simple but effective algorithm for filling the interior of a bounded region. Binary boundary coding is proposed to classify and code pixels on the closed boundary contour as start and end points. Then filling the interior is performed along the horizontal raster direction from the start points to the end points.

II. The Proposed Interior Filling Algorithm

Chain coding pixels on the extracted boundary assigns one of eight values (1 through 8) referring to its directional information as shown in Fig. 1. The boundary pixels coded with these values along the clockwise direction are illustrated in Fig.2.

It may be noticed from the coded boundary image that if filling the interior of the boundary can be done along the horizontal raster direction from left to right[2], then all of arrowhead-up codes (6,7 or 8) become the start filling points

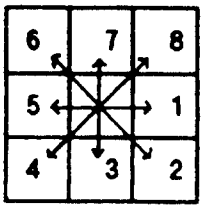

Fig.1. 8-directional chain coder.

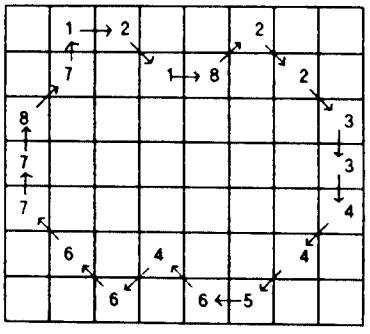

Fig.2. Chained boundary.

and all of the arrowhead-down codes (2, 3 or 4), the end filling points.

Based on this concept, binary boundary coding is proposed to assign the code 'S', as the start filling point of the interior, to the boundary pixels in the arrowhead-up direction and the code 'E', as the end filling point of the interior, to the ones in the arrowhead-down direction. In this coding process, 'S' should be coded into the current (arrowhead position) boundary pixels, whereas 'E' into the immediate previous (arrowtail position) boundary pixels. They are shown in Fig.3.

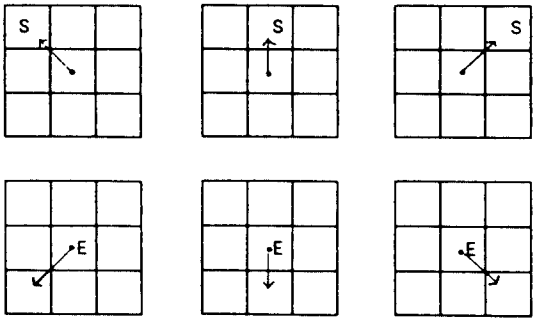

Fig.3. Binary boundary coder.

If a boundary pixel to be coded with 'S' is already coded with 'E' or a boundary pixel to be coded with 'E' is already coded with 'S', then we change this code into code 'I', as a part of the interior pixels or whatever codes we assign. This is the case of vertex or multijunction pixel. If a boundary pixel is not assigned by any of two codes during the coding process, then we assign 'I' to this pixel, which is the tangent pixel of the contour in the horizontal raster direction. The result applied to the previous example is shown in Fig.4.

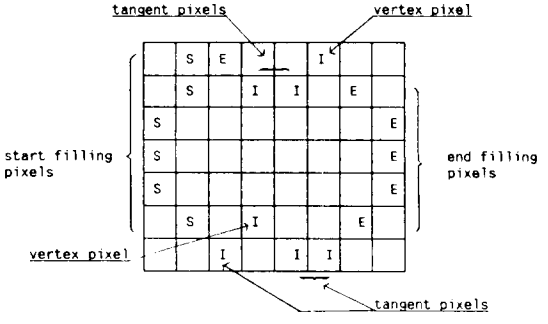

Fig.4. Coded boundary pixels by binary boundary coding.

After these coding processes of the boundary, filling the interior may be done easily. It starts from the upper left-hand corner of the image. X increases left to right and Y increases top to bottom. If we encounter code 'S', then fill the pixels in the horizontal raster direction until encountering code 'E', Code 'I' between from codes 'S' and to code 'E' is ignored and simply replaced by itself in the filling process. Code I's in other places remain without change since they are already parts of the interior. The final image having the filled interior of the bounded region is shown in Fig.5.

III. Experimental Results

To see the validity of the proposed algorithm, several experiments having various vertex points and/or multi-junction points were performed. They are shown in Fig.6, 7 and 8.

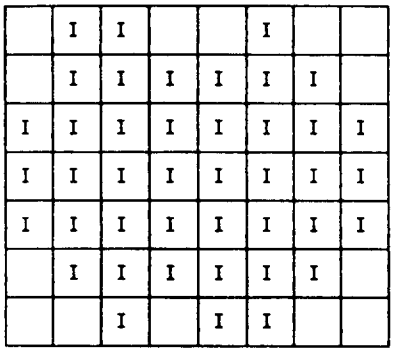

Fig.5. Filling the interior of the bounded region.

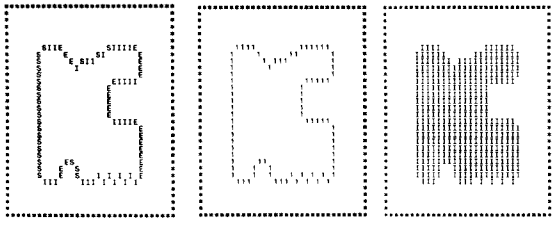

Fig.6. Example with various vartices: (a) Contour data; (b) Coding 'S', 'E' or 'I'; (c) Filling the interior.

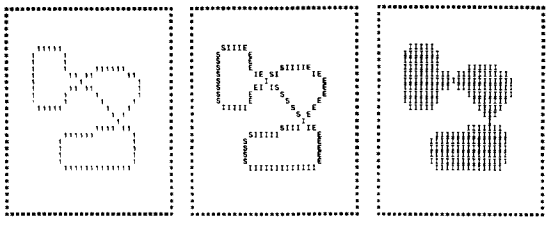

Fig.7. Example with various multi-junction points: (a) Contour data; (b) Coding 'S', 'E' or 'I'; (c) Filling the interior.

IV. Conclusion

We proposed a very simple but effective algorithm for filling the interior of a bounded region

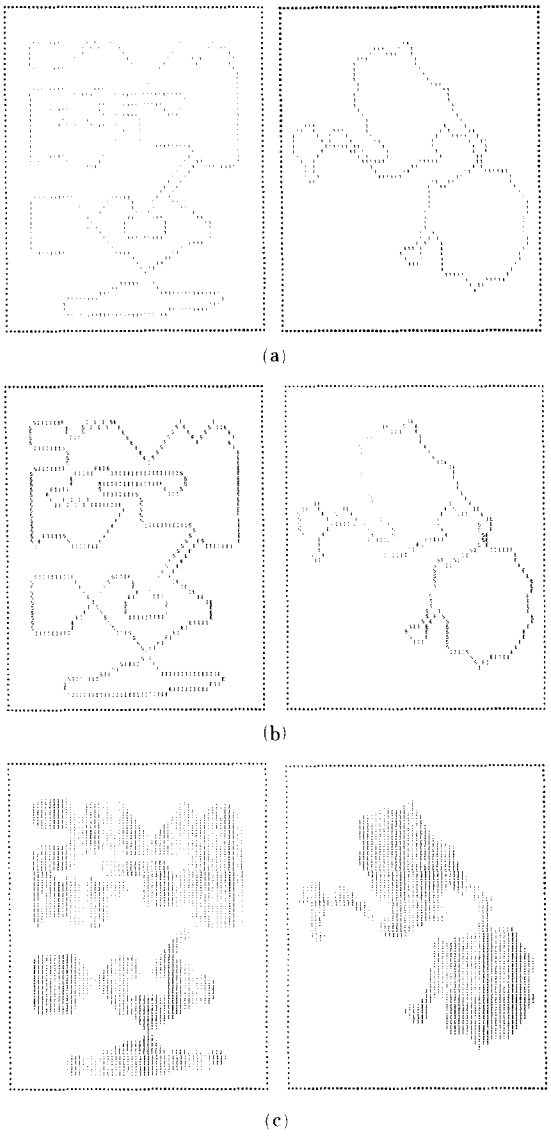

Fig.8. Filling the boundary contour having vertex points and/or multijunction points: (a) Contour data; (b) Coding 'S', 'E' or 'I'; (c) Filling the interior.

when its contour is given. As the binary boundary coder follows the chained boundary contour in the clockwise direction, boundary pixels are classified and coded as the start points of filling interior and as the end points. Then filling the interior is done from the start point to the end point along the horizontal raster direction.

The major advantages of the propose algorithm are as follows:

1) can avoid difficult parity checking in the vetrtex point or tangent line.
2) does not need seed points and speeds up computational time.
3) does not need the complicated classification of the vertex and/or multi-junction points as a part of interior or not.
4) is very simple and effective for filling the interior of boundary contour.

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